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At the Crossroads of Arts and Cultural Education: Queries Meet Assumptions

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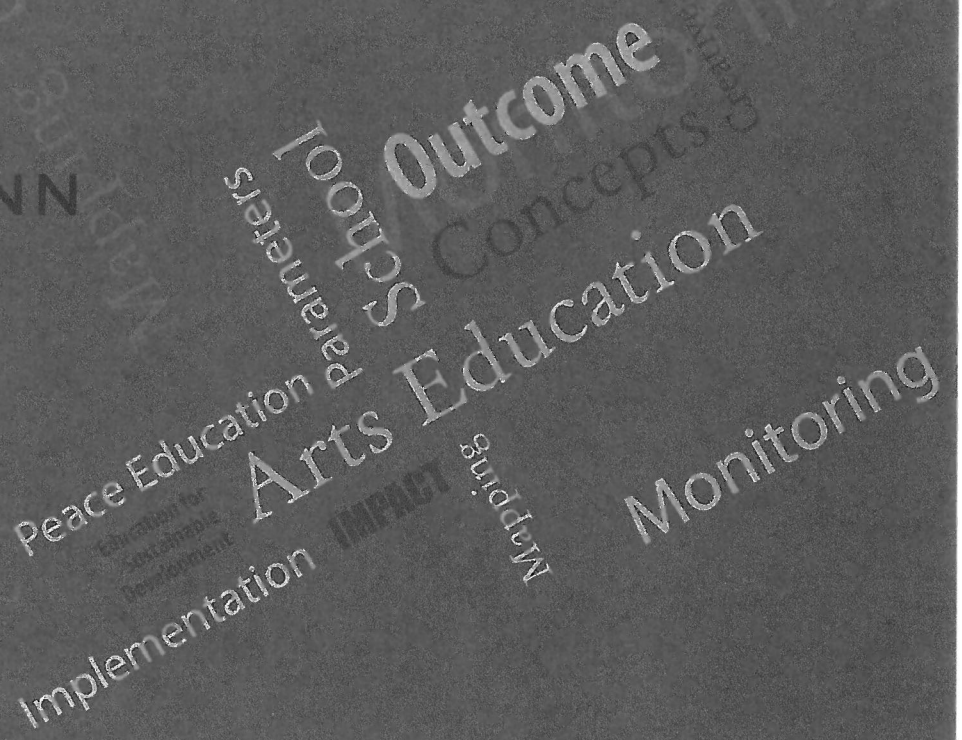

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Kathryn Grushka, Miranda Lawry, Neville Clement, Alice Hope and Andy Devine

Visual Art Education: At the Crossroads of Art, Science and Spatial Learning

This article questions if engaging with concepts from science and expressing them through visual artistic forms enhances learning about the self and the world. A small selection of visual art students ranging from 15-17 years old from local schools in regional Australia explored a scientific inquiry question through their artmaking. An analysis of the exhibition works of two students from this selection reveals how they applied spatial, abstract and metaphoric reasoning when encountering their scientific inquiry. The results shed light on the potential of visual epistemologies and prompt visual educators to challenge assumptions and re-examine links between art and sciences, as they both connect cognitive-affective thought in learning.

Introduction

Artists and scientists ask big questions driven by deeply felt personal inquiry. Art and science are increasingly being connected (Root-Bernstein, 2008). In visual education these links are under explored in research even in light of integrative thinking between the arts and sciences (Siler, 2015; Sill, 2001), as well as the richness of cross-pollination between these domains (Farman, Barr, Philp, Lawry, Belcher & Dastoor, 2015). This chapter asks, 'Can art and science, the apparent antithesis of one another, come together in the application of art methods to enhance student learning about scientific knowledge'. This question is examined through an examination of integrative art/science learning outcomes, of a small group of secondary school art students selected in the *High Achievers Program* (HAP) to participate in a regional Australian University foundational fine art course.

The High Achievers Learning Intervention Project

The project targeted high achieving school students offering them an opportunity to get a 'taste' of university. The students in this project were identified for their talent in visual arts. The students enrolled in first-year Fine Art university course and studied on Friday afternoons for 13 weeks at a local High School with a Fine Art tutor from the university. Success in this course ensures credit when the students (n = 12) choose to enrol at the university. The Fine Art course introduces the basic core skills required to devel-

op and explore the expressive potential of drawing, painting or printmaking practices. It considers the basic material, technical, historical, theoretical and conceptual dimensions of these media with a focus on experimentation and reflection on cognitive processes of learning. At the end of the program, students were invited to exhibit their final artwork in an exhibition hosted by the University Gallery and share their work with the general public.

Inquiry Methods

A qualitative inquiry approach was applied to examine student learning from the HAP Program. We collected a range of data including: short student surveys; audience surveys; image elicitation interviews with the tutor; summative student focus group conversations, image analysis of artworks, art diaries and artist statements. We examined the learning outcomes of two students, Mirima and Stephanie, specifically seeking to identify their ways of thinking and representing scientific concepts. We considered, (i) which sensory modalities and visuospatial strategies were preferred by the students for conceptual and reflective thinking, and (ii) what level of conceptual complexity, affective and metaphoric thinking were linked to their artwork?

Drawing on interpretive phenomenology (Smith, Flowers & Larkin, 2009), the analysis aims to shift from the particular to the shared and from the descriptive to the interpretive. Presenting the personal meaning making processes of the students through the lens of the "researcher-as-interpretive bricoleur" (Denzin & Lincoln, 2005, p. 189). The two lenses overlaid and pieced together in our examination were: (i) an agreed interpretation by the researchers of how the data revealed students' learning experiences and conceptual knowledge within their works and (ii) the independent researcher not involved in the delivery of the project analyzing students' own decision making processes, and the emergent common themes between their works.

Art Science Visualisation

The relationship between arts-science learning requires re-examination as recent insights from cognitive psychology and neuroscience show several links. Science learning has a long history of visual cultures (Pauwels, 2006) and engages multiple semiotic systems (Danesi, 2010). In addition Siler (2015) and Winner, Goldstein and Vincent-Lancrin (2013) claim that creativity, innovative thinking, problem-solving, critical thinking, and other related cognitive processes are self-evident in the arts and sciences. ArtScience thinking, "integrates synesthetic experience with analytical exploration" (Root-Bernstein, Siler, Brown & Snelson, 2011, p. 192). Kolijn (2013) identifies the skill of observation and image construction as a connection between art and science, since the scientific illustrator engages artistic judgements concerning visualization's properties like form, colour and style.

Images extend human cognition (Stafford, 2007; Tversky, 2015). Heuristic sketches provide a means of exploring and communicating ideas and were used by notables like

Leonardo Da Vinci and Freud (Du, 2012; Eppler & Burkhard, 2006). Heuristic imagery crosses any artificial divide between the arts and the sciences because both use visual representations as cognitive extensions. While art and science imagery operates in different epistemological contexts with underlying semiotic differences, they both employ the same cognition and harness integrative thinking. Integrative thinking connects the cognitive and affective functions of creative, divergent, analytical and metaphoric, proprioceptive or kinaesthetic cognition and dimensional or spatial thinking (Siler, 2015).

Art Science: Connecting Cognitive-affective, Metaphoric, Abstract and Spatial Thought

Learning in art like science learning does not function in isolation: it is influenced by perception, affect, cognition and memory (Phelps, 2009). The intuitive-emotional system of the brain energizes the neocortex in providing impetus for both artists and scientists (amongst others) for creative problem solving and self-expression (Panskepp & Biven, 2012). Stafford (2007) places the cognitive work of images, like visual metaphors as the ability to capture both the external and inner worlds of human experience and through the imagination "hold mental content in an external form" (p. 28). Metaphors "help scientists, artists and other practitioners to link experience, intuition and imagination for erecting conceptual scaffolding" when literal language proves inadequate (Wilson, Hawkins & Sim, 2015, p. 155). Siler (2015) holds that symbolic art metaphorically interprets the brain's intuitive and analytical reasoning. Metaphors, however, are culturally contextual and therefore provisional (Wilson, 2014). Both artists and scientists develop metaphoric meanings from observation and experience.

Tversky (2005) states that spatial thinking is part of everyday activity and "serves as a basis for abstract knowledge and inference" (p. 209), they are also processes exploited by artists as they externalize thought through the aesthetic, behavioural, cognitive and/or communicative (Tversky, 2011). Visuospatial reasoning connects to diagrammatic reasoning to support mental processes. Transformations (such as resizing, rotation, location changing) by visuospatial reasoning can be performed on part or all of an object, like in figure construction or drawing (Tversky, 2005). Knauff (2013) identified that within the ambiguity of sketches lie latent discoveries, inferences, and reinterpretations via rearrangement. Additionally, Grossner and Jannelle (2014) identify words specific to spatial reasoning such as pattern, symmetry, shape, position, scale, left and right are directive that also find application in visual design and mathematics.

Findings

The findings reveal how life world and personal narratives triggered individual visual representation practices across the student group. In the analysis of the works of Mirima and Stephanie their embodied learning reveals individual reasoning, choice of subject matter and scientific concepts.

Stephanie

A singer, Stephanie's artwork has emerged from her personal interest in music, and her cognitive-affective relationship between vision and sound (synaesthesia), a topic of continued fascination for artists (Tolley, 2001). My "artworks try to express the connection people have with music and how this connection is different [for] every person". The scientific concept of synaesthesia (where one sensory or cognitive pathway leads to automatic or involuntary stimulation of a second cognitive pathway) was applied to herself and her colour-blind brother's experiences, "two views of the same song". "My use of synaesthesia acts as a code to interpret each colour into the letter I have associated it with, which... is arranged into the lyrics of a song" (Figure 1, below). She juxtaposes her narrative with her brothers and finds "there are very similar colour relations between both works, but to [someone] who [is] colour blind, they look exactly the same".

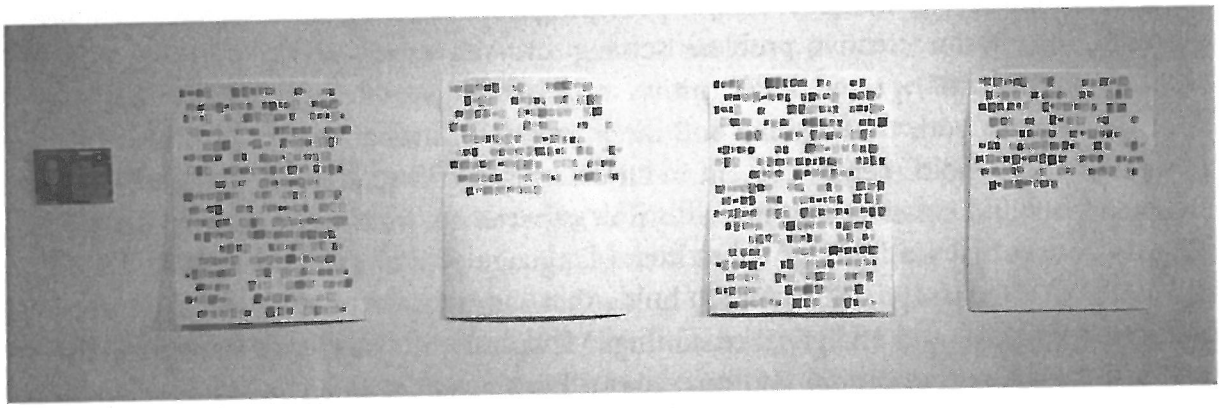

Figure 1: Stephanie "Depth"

Stephanie drew on multiple modalities from real experience and then abstracted them. She created a visual representation of her own experiences and re-presented her dialogue with her brother about colour and sound as two different, but similar artworks. Stephanie describes art making as "self expression" and an opportunity to "communicate the things you love... with other people". Drawing on her own phenomenological experiences of singing, of reading music's notational form and of feeling music, she created a visual metaphor to carry her insights to others. We may link Stephanie's work to musical notation, but she created her own visual code, interpreting sound as colour and relying on her own experiences of to guide this process.

Stephanie explains, that her work "Depth" aimed to "... stand out to the viewer's eye" so that "you have to look with depth to understand that it isn't as simple as it first may seem". She applied the science concept synaesthesia within the production of abstract art. She selected coloured rectangles, to symbolize words and sounds and organised them within the semiotic structures of a music script. The abstract form of her work employs integrative thinking. The skill of this kind of integrative thinking may have application more generally in her learning.

Mirima

Mirima's collection of work, entitled 'Circumnavigation', "explores the links between my environment and my moods, cognitions and emotions as I go about my weekly routines" (Figure 2, below). She reflected that, "my mind immediately turned to the intricacies of the relationships between my thoughts." The level of sophistication in her spatial and diagrammatic reasoning demonstrates how artmaking and its abstract reasoning can be used to solve problems relating to space, time and feelings as they inform identity work. She says, "[the] concept of my work became an exploration of my emotions in relation to travel and the other daily activities that dominate my life as a student".

Mirima was interested in "associations between shapes, colours and emotions"; she considered how feelings throughout different times of the days could be rendered. Mirima's collection of work maps, of intensities and connections between events and emotions crossed spatial realms, such as time, place, and emotional states. She further refined these multiple spatial systems into a series of single representations (see Figure 2: Day 1 and Day 2 below).

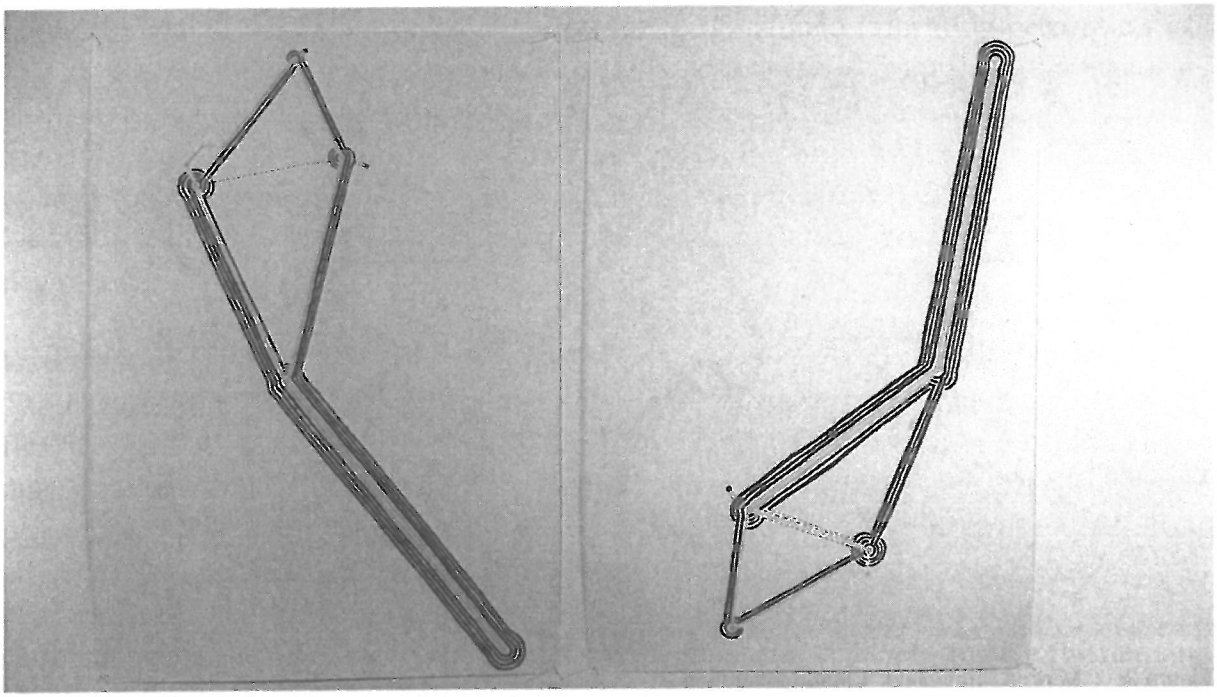

Figure 2: Mirima "Day 1" and "Day 2" Circumnavigation

Mirima and Stephanie's works reveal levels of reflexivity and artistic conceptual intentionality as they refine and abstractly map their inner thoughts and feelings, select subject matter, medium, colour, shape and spatial arrangement. Both students talked about how the world of experience and self-reflection informed personal metaphors. These metaphors were a powerful tool for boundary crossing and integrative thinking. For Mirima the metaphoric images are personal maps that capture and communicate relationships between time, place and emotion.

The pedagogical approach of the university tutor was to commence a dialogue with the students about their interests, drawing out reflective questions about science. The students were encouraged to research other artists who explored a similar subject matter, as opposed to spending time researching their so-called 'science topic'. Stephanie looked at artists such as Kandinsky and Klee, and Mirima investigated graphic forms related to travel, such as underground maps and later, the Bauhaus movement. Deeper into her study, Mirima became aware of the influence of Aboriginal art from Western Australia in her home. She reflected that she may have unconsciously re-conceptualised their spatial ideas in her work. Her artwork, entitled 'Travelling…' "sums up my travel experience, different parts of my life intersecting, warning signs, winding bus trips, ending in an infinite line of curiosity" (Figure 3, below).

In Figure 3, *'Travelling'* abstract diagrammatic reasoning is applied to support internal mental processes. Mirima reflects that, "artwork can effectively communicate aspects of human existence … such as movement through space … changes in internal and external states." "She moved from rigid painting between masking taped lines to drawing this lovely organic line and filling it with that representation of emotion … it was her narrative over those ten weeks"(tutor). Mirima, like Stephanie, used her embodied experience to drive discovery and perform her own symbolic visual system of understanding.

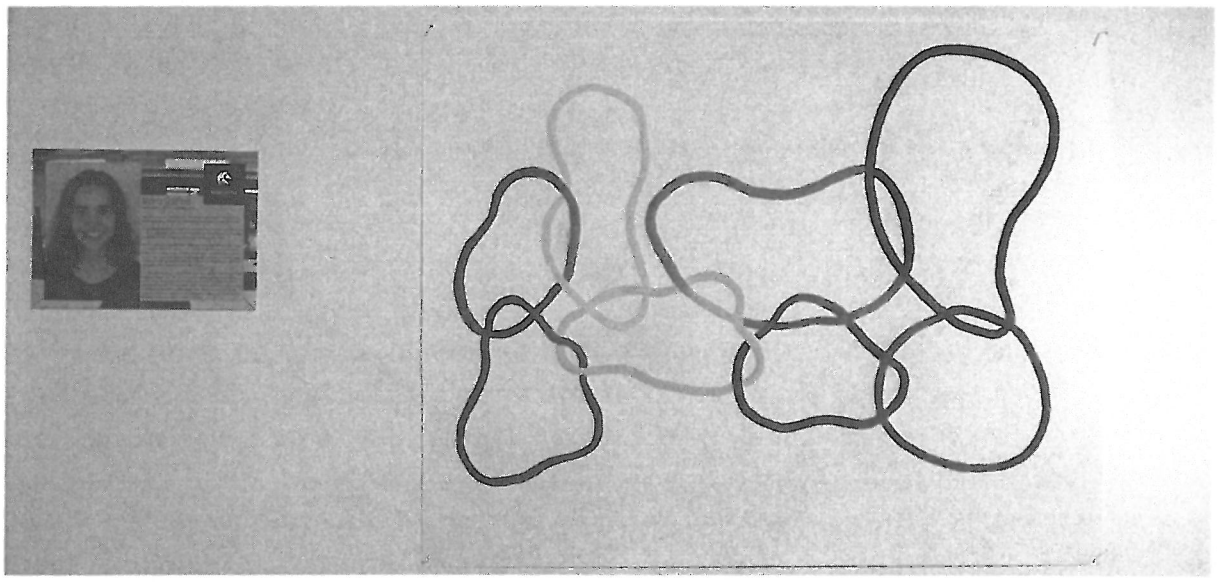

Figure 3: Mirima "Travelling" Circumnavigation

Discussion

The works of Mirima and Stephanie draw attention to how artmaking can build the cognitive skill of abstract reasoning with metaphoric representational solutions to refine conceptual ideas. Both students selected a phenomenon that has been the preoccupation of scientists and artists. Stephanie chose the synesthesia of sound and colour and Mirima, the spatiality of travel represented as both an internal and external mapping of ex-

perience. They each drew on their preferred individual sensory modalities and applied visuospatial strategies to support their conceptual and reflective thinking. Most importantly they used imagination as a method to build diagrammatic and spatial solutions as ways of representing their inquiry. One audience observer commented that they created "perceptions", not just "illustrations" of their chosen science concept. In fact, this is a position often associated with most successful scientists when presenting new knowledge. As noted by Root-Bernstein (2008) and Csikszentmihalyi (1996) scientific creativity draws on the same aesthetic tools as art.

Cognitive and Affective Thinking

Visual art thinking pays attention to personal experience and embodied understanding to drive engagement, discovery and meaning making. It is emotion that interacts with cognition, attention, perception and memory (Phelps, 2009). Both the arts and the sciences harness this emotional system of the brain as it is energizes in creative problem solving and self-expression (Panksepp & Biven, 2012). Both Stephanie and Mirima externalized their 'internal' emotional space with a focus on *colour, shape and time.* Time represented as movement through space (Mirima) and music as the duration of sound, time and colour (Stephanie). Artmaking was an act of location, using the body and the physical plane of the paper as the cognitive navigational field informing perception and spatial relationships. Mirima converted "scientific information" from the different neural modalities; visual, emotional, physical, into concrete spatial information. Her artworks demonstrate her high spatial ability and she was "not bound by the visual" but extrapolated spatial relations from multiple modalities (Knauff, 2013). On Stephanie's artwork her tutor referred to her "Beautifully minimalist artworks that serves as emotional journey of a conscious person aware of her surrounding, and her state of mind".

Visuospatial Thinking

The use of visuospatial reasoning is highly visible in Mirima's "Circumnavigation" series. Her parents saw her artwork as "a story line ... a bird's eye view of journeys". Mirima's work has links to other ways of knowing used by scientists. She reflects "graphs in science, maths and geography are very similar to the visualisation in my art making practices". She externalised her experience of movement through space, on the "basis of rules and heuristics rather than imagistic situations" (Hegarty, Stieff & Dixon, 2014). Mirima's externalising of experience employed high spatial ability, to reduce the demand on memory and augment cognitive work (Tversky, 2001) in order to refine her abstract ideas. Mirima explains, "as a visual learner my work helps me come to a deeper understanding of myself".

Stephanie merged her new understanding of the art/science concept of synaesthesia in order to create artworks of coded aesthetic. Her spatial visualisation skills extended her understanding of the science of synaesthesia opening new conversations about the phenomenon. The spatial organisation of this work allows the audience to make meaning from the information presented as it "reflects [the]conceptual organization" being explored (Tversky, 2001, p. 86).

Metaphoric Thinking

Making meaning in science and art requires the development of conceptual ideas and finding ways to represent these ideas. Both artists and scientists develop metaphoric meanings from observation and experience. Metaphors help to link experience, intuition, analytical reasoning and imagination as a form of conceptual scaffolding (Siler, 2015; Wilson, 2014; Wilson et al., 2015). Metaphors, however, are culturally contextual, art and science imagery operate in different epistemological contexts or ways of knowing with underlying semiotic differences. Conceptual complexity, affective and metaphoric thinking underpin both students' art series and students in this study freely accessed the semiotic systems that best represented their ideas, acknowledging that at times their works were 'illustrations' of concepts or re-contextualisation of a scientific visual system.

The findings challenge mainstream assumptions about art and science learning arguing in support of the idea that they are more alike than different (Maeda, 2013). Spatial reasoning functions epistemically and finds expression in discrete semiotic practices, yet these can be re-contextualised in order to support the unique cognitive development of all learners. Even though this in depth analysis of only two students is limited in terms of size and number, findings reveal that there is potential for visual art to build the abstract reasoning skills of students in classrooms. The works of Stephanie and Mirima provide insights into the relationship between cognitive-affective thinking, visuospatial reasoning and metaphoric relationships when representing ideas. The power of visual art processes is that they are agents for creative thought, build divergent and analytical reasoning, employ multisensory cognition in the integrative thinking between visuospatial and metaphoric thinking (Siler, 2015).

Conclusion

This chapter focused on the application of visual pedagogies to enhance student integrative thinking about scientific knowledge through embodied and performative acts. It argues that art and science are not antithetical and that art pedagogies, like scientific thought are imaginative, experimental, process driven, and use abstract thought in order to understand the world. It revealed that embodied artmaking supports cognitive capacities, particularly the way that images serve as scaffolds for abstract thinking and metaphoric and visuospatial thinking. It concludes that artmaking is potentially both a stimulus and an opportunity for visual engagement with the epistemic fields of the sciences through their strong interconnectedness to visual art education in learning.

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